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FORM PTO-1390 (REV. 9-2001) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: CU-2825 RJS

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 10/049414

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/AU00/00898	28 July 2000	10 August 1999

TITLE OF INVENTION: A VEHICLE WITH A STEERABLE WHEELSET

APPLICANT(S) FOR DO/EO/US: Scott Phillip Neale TAYLOR

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is attached hereto (required only if not communicated by the International Bureau).
   b. [ ] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [X] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [X] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. [ ] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. [ ] Other items or information:

Express Mail Label No.
L 698184378

U.S. 10/049414	INTERNATIONAL APPLICATION NO. PCT/AU00/00898	ATTORNEY'S DOCKET NUMBER CU-2825 RJS

21. [X] The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 1040.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	35 - 20 =	15	x **$18.00**	$ 270.00	
Independent claims	1 - 3 =	0	x **$84.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$ 1310.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +				$	
SUBTOTAL =				$ 1310.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$	
TOTAL FEES ENCLOSED =				$ 1310.00	
				Amount to be refunded:	$
				charged:	$

a. [X] A check in the amount of $ 1310.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 12-0400 . A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

Richard J. Streit
NAME

25765
REGISTRATION NUMBER

February 8, 2002

DOCKET: CU-2825

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

APPLICANT: Scott Phillip Neale TAYLOR)
)
TITLE: A VEHICLE WITH A STEERABLE WHEELSET)
)
COMPLETION OF PCT/AU00/00898 filed 28 July 2000)

The Commissioner for Patents (DO/EO/US)
Box PCT
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

Please amend the application being filed herewith under 35 USC 371.

IN THE CLAIMS:

Please cancel claims 1-12 from the PCT application as filed as well as claims 1-13 from the claims attached to the International Preliminary Examination Report and substitute new claims 14-48 as attached to the substitute specification.

REMARKS

The aforesaid claims are based on the claims attached to the International Preliminary Examination Report, with amendments to place the same in better condition for examination under U.S. rules of practice.

A substitute specification is enclosed and is based on the following materials:

- Pages 1-3 of the PCT application as filed
- Page 4 as attached to the International Preliminary Examination Report
- Pages 5-10 of the PCT application as filed
- New claims 14-48 as referenced above
- The abstract as filed in the PCT international application
- 7 sheets of drawings as filed in the PCT international application

Favorable consideration of this application is respectfully requested.

Respectfully submitted,

February 8, 2002
Date

Attorney for Applicant

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Scott Phillip Neal TAYLOR
US Completion of PCT/AU00/00898
A VEHICLE WITH A STEERABLE WHEELSET
Docket: CU-2825

SUBSTITUTE SPECIFICATION

A VEHICLE WITH A STEERABLE WHEELSET

TECHNICAL FIELD

This invention relates to a vehicle with a steerable wheelset. Whilst the invention is primarily described with an embodiment particularly suited for use with Automated Guideway Transit (AGT) systems of the type which use small, individual vehicles, capable of operating at high speeds, the present invention is also suitable for use with a variety of other rail or guideway systems.

BACKGROUND

There are a number of known vehicles adapted to travel on rail or guideway systems which have steerable wheelsets.

One such system is disclosed in US Patent 4,982,671 (Chollet et al), and relates to a track guided vehicle. Such a vehicle is supported on bogies, where each bogie contains two wheelsets. Magnetic (or other) sensors are used to detect the lateral position of the bogie with respect to the track on which it is running. At least one sensor detects the angle between the two wheelsets. The two wheelsets are connected via linkages and actuators, such that the angle between the wheelsets can be altered to steer the bogie. A servo-control circuit receives signals from the sensors and controls the actuators to steer the wheelsets in response to the detected lateral position of the bogie.

Another known system is disclosed in European Patent 374,290 (Girod et al), and relates to a track guided vehicle. Such a vehicle comprises four wheels that can be independently steered. Laser sensors, located at the front and rear of the vehicle, are used to detect the difference between the track centreline and the vehicle longitudinal axis. A servo-control mechanism controls the steering actuators in order to steer the wheels in response to the sensed signals.

A disadvantage of both of these arrangements is that the lateral forces at the wheel-rail contact zone must serve a dual function, namely to steer the bogie and to oppose any lateral force, such as the centrifugal force experienced by a vehicle while cornering. Consequently the force available for steering the bogie is limited to the difference between the total available force and that already being used to oppose any external lateral forces. In a rail application where a steel wheel rolls on a steel rail, the total available force may be very low. This available force may be substantially required to react centrifugal force, with very little remaining force available to steer the wheelset leading to frequent contact between the wheel flanges and the rails.

A further known system is disclosed in US Patent 5,730,064 (Bishop), and relates to a self-steering bogie for track guided vehicle. The wheelsets are arranged such that a curvature in the rail generates a twist angle between the two wheelsets in the bogie when viewed in end elevation. The mechanism connecting the two wheelsets is arranged so as to steer the wheelsets, in response to rail curvature. A disadvantage of this arrangement when applied to small vehicle guideway systems, which typically use much sharper curves than normal rail systems, is the steer error resulting from twist angle supplied by rapidly changing superelevation. This may add to or subtract from the ideal steering angle required, causing the wheelset to deviate from its idealised path.

Preferably the present invention overcomes the above mentioned disadvantages by providing a vehicle with a steerable wheelset in which the effect of lateral or disturbing forces on the vehicle is minimised.

SUMMARY OF INVENTION

In one aspect the present invention is a vehicle with at least one steerable wheelset adapted to run on a guideway having two primary running faces laterally offset about

a guideway centreline, the wheelset comprising a pair of wheels, each wheel located on opposite sides of the wheelset adapted to

engage with a respective one of the two primary running faces, the vehicle further comprising sensing means for sensing lateral displacement of the wheelset with respect to a longitudinally disposed reference path, the sensing means producing a signal for a control system operably connected to an actuating means to steer the wheels in response to the sensed lateral displacement, **characterised in that** the axes of rotation of the wheels and the primary running faces are inclined downwardly towards the guideway centreline.

In a first embodiment each wheel exerts an engagement force with its respective primary running face, the engagement force on each wheel comprising a perpendicular component to its respective primary running face and a parallel component to its respective primary running face substantially transverse to the guideway centreline, wherein horizontal forces acting on the wheelset substantially perpendicular to the guideway centreline are substantially resisted by the sum of of the horizontal vectors of the perpendicular components.

In a second embodiment embodiment each wheel exerts an engagement force with its respective primary running face at a contact zone, the engagement force on each wheel comprising a first component perpendicular to its respective primary running face and a second component parallel to its respective primary running face substantially transverse to the guideway centreline, wherein a first plane perpendicular to the axis of rotation of one of the wheels passes through its respective contact zone, and a second plane perpendicular to the axis of rotation of the other wheel passes through its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to

the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

Preferably the intersection line passes through the centre of gravity of vehicle.

It is preferred that the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

It is preferred that the longitudinally disposed reference path is substantially contiguous with the guideway centreline.

Alternatively, it is preferred that the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

It is preferred that a secondary running face lies immediately adjacent to, and substantially parallel to, at least one primary running face.

It is preferred that the longitudinally disposed reference path is contiguous with the second running face.

Alternatively, it is preferred that a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

It is preferred that at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

It is preferred that the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an example of a vehicle according to the prior art, with two steerable wheelsets and incorporating steering sensors, actuators and a controller;

Figure 2 is a wheelset as found in the vehicle in Figure 1, showing the forces acting at the wheel-to-guideway running faces;

Figure 3 is a graph representing a typical relationship between side-force and slip angle for a wheel of the wheelset in Figure 2, and showing the force available for steering the wheels;

Figure 4 shows a schematic representation of a vehicle in accordance with a first embodiment of the present invention;

Figure 5 shows a schematic representation of a vehicle as shown in figure 4 when the vehicle is in a turn;

Figure 6 is a wheelset of the vehicle as shown in Figures 4-5, showing the forces acting at the wheel-to-guideway running faces;

Figure 7 is a graph similar to Figure 3, showing the force substantially available to steer the wheels in accordance with the first embodiment of the present invention;

Figure 8 is an illustration of the forces which act on the wheelset of the vehicle shown in Figure 6.

Figure 9 is a wheelset and rails as described in a second embodiment of the present invention;

Figure 10 shows a wheelset which is following a longitudinally disposed reference path other than the guideway centreline or secondary running face, according to a third embodiment of the present invention.

MODE OF CARRYING OUT THE INVENTION

Figures 1 and 2 show a vehicle running on a guideway (or track) of the type described in prior art. Such a vehicle incorporates two steerable wheelsets 1, attached to a vehicle body 2, and each wheelset 1 comprising axle 10 and two wheels 12. Steering actuators 3, are used to control the angle of the wheels with respect to the body. Sensors 4, detect the path error between the vehicle and guideway 5. A controller 6, processes the signals from the sensors and provides a control output to steering actuators 3. Upon detecting a path error, wheelsets 1 are steered in order to minimise the error.

In such a vehicle, axles 10 are substantially horizontal, as shown in Figure 2. When a lateral force F is applied to the vehicle body 2, it is reacted by the wheel-to-guideway engagement forces. These reaction forces can be resolved into perpendicular components, A_N and B_N, and parallel components, A_T, B_T. When a wheel is steered at an angle to its heading, generating a slip angle, small levels of slip at its contact zone generate a lateral force (A_T, B_T). This lateral force is related

to this slip angle, with a typical relationship of the form shown in the graph of Figure 3. Such a relationship depends on both the wheel and guideway materials, along with their surface texture and lubrication. The available side force reaches a maximum at a slip angle δ_1, beyond which no additional side force is available. In the example shown in Figure 2, wheelset 1 is steered so that lateral force F is reacted by a combination of A_T and B_T where A_T is equal to C_1 as shown graphically in Figure 3. To generate a force C_1 wheelset 1 must be steered so that wheel 12 generates a slip angle δ_0 to its heading. Only the remaining force C_2 is available to steer wheelset 1. If the required side force exceeds C_2, steering control is lost, the wheel slides in the direction of force F and is unable to follow a desired path. In such an event, the wheelset must rely on other means, such as wheel flanges, to ensure it remains safely on the guideway.

Figures 4 to 6 show a first embodiment of a vehicle according to the present invention comprising steerable wheelsets 21, each comprising axle 26 and two wheels 15 running on primary running faces 54 of guideway 19, attached to vehicle body 16. Steering actuators 17, are used to control the angle of wheelsets 21 with respect to vehicle body 16. Sensors 18, detect the lateral displacement between the vehicle and guideway 19. Controller 20 processes the signals from sensors 18, and provides an output to the steering actuators as a function of the lateral displacement of wheelset 21 with respect to guideway centreline 39. Upon detecting a lateral displacement error, wheelsets 21 are steered in order to minimise the error.

As shown in Figure 6, axes of rotation 28 of wheels 15 (mounted to stub axles 25) are inclined downwardly towards guideway centreline 39, as are primary running faces 54 at the wheel-to-guideway rolling interface. When a lateral force F is similarly applied to vehicle body 16, it is reacted by the wheel-to-guideway engagement forces. These can be resolved into first perpendicular components, P_N and Q_N and second parallel components, P_T and Q_T. Each of these has a

component parallel to the applied lateral force F, and in combination react against this force.

On entering a turn, sensors 18 detect the deviation of the vehicle from guideway centreline 39, and controller 20 responds by steering wheelset 21 in the direction to reduce the deviation to zero. The resulting slip angle δ produces lateral forces at the wheel-to-guideway interface, causing the vehicle to accelerate toward the instantaneous centre of curvature. The centrifugal force F, acting on the centre of gravity 50 of the vehicle, is substantially reacted by an increase in the normal force, P_N, on the outer wheel, rather than an increase of the tangential forces, P_T and Q_T. If P_T and Q_T are small, then the wheels do not need to be operating at a very large slip angle δ_o as shown in Figure 7. As a result, most of the maximum available tangential force, C_2, can be used to steer wheelset 21 and maintain its alignment with guideway centreline 39.

It is preferred that vehicle centre of gravity 50 and wheels 15 are arranged such that centre of gravity 50 is near the intersection line 52 of wheel planes 51. In this configuration, the centrifugal forces or external disturbance forces acting on centre of gravity 50, are substantially resisted by an increase in the normal force, P_N, on the outer wheel, and corresponding decrease in the normal force Q_N on the inner wheel. As shown in Fig 8., the difference between the horizontal component P_H of P_N and the horizontal component Q_H of Q_N, substantially resists the sum of the centrifugal or external disturbance force F.

Figure 9 depicts a second embodiment of the present invention, where the vehicle has a wheelset 21 comprising wheels 15 adapted to run on a guideway in the form of rails 19. Sensors 18 detect the proximity d_1, d_2 of the respective wheel 15 to the respective secondary running face 38 on rail 19. Sensed proximities d_1, d_2 are

averaged to generate the lateral position of the centreline 49 of the wheelset 21, with respect to the guideway centreline 39. In this embodiment each of the wheels 15 have a respective flange 37. Flange 37 engages with respective secondary running face 38 on rail 19 in the event of a steering failure, or excessive side load imparted on the vehicle via lateral acceleration or side wind loads. In other not shown embodiments, sensors 18 may detect the proximity of the wheels to some other feature on rail 19.

In a third embodiment of the invention as shown in Figure 10, sensors 18 may sense a different path to that of guideway running faces 40. In this embodiment a longitudinally disposed reference path 41, corresponding to the guideway centreline 39, is used. However, it should be understood that such a path may physically lie between guideway running faces 40, as depicted by phantom lines as reference path 41a and sensor 18a, or outside guideway running faces 40, as depicted by phantom lines as reference path 41b and sensor 18b. Alternatively the reference path may be a virtual path, bearing some predetermined varying relationship to the guideway running faces 40.

In other not shown embodiments other means of supporting and steering the wheels may be used. These include steering of individual wheels about individual steering axes, rather than steering complete wheelset 21. Sensors 18, are attached to wheelset 21, and sense its lateral displacement with respect to each primary running face 54 of guideway 19 and hence with respect to guideway centreline 39. Sensors 18 are preferably located ahead of wheelset 21 and are connected to controller 20. In other not shown embodiments, sensors 18 may be located ahead, beside, and/or even behind the wheels.

Sensors 18, controller 20 and actuators 17 may include hydraulic or electrical devices and combinations thereof.

It will be recognised by persons skilled in the art that numerous variations and modifications may be made to the invention without departing from the spirit and scope of the invention.

CLAIMS:

14. A vehicle with at least one steerable wheelset adapted to run on a guideway having two primary running faces laterally offset about a guideway centerline, the wheelset comprising a pair of wheels, each wheel located on opposite sides of the wheelset adapted to engage with a respective one of the two primary running faces, the vehicle further comprising sensing means for sensing lateral displacement of the wheelset with respect to a longitudinally disposed reference path, the sensing means producing a signal for a control system operably connected to an actuating means to steer the wheels in response to the sensed lateral displacement, the axes of rotation of the wheels and the primary running faces are inclined downwardly toward the guideway centerline.

15. A vehicle as claimed in Claim 14, wherein each wheel exerts an engagement force with its respective primary running face, the engagement force on each wheel comprising a perpendicular component to its respective primary running face and a parallel component to its respective primary running face substantially perpendicular to the guideway centerline, wherein horizontal forces acting on the wheelset substantially transversed to the guideway centerline are substantially resisted by the sum of the horizontal vectors of the perpendicular components.

16. A vehicle as claimed in Claim 14, wherein each wheel exerts an engagement force with its respective primary running face at a contact zone, the engagement force on each wheel comprising a first component perpendicular to is respective primary running face and a second component parallel to its respective primary running face substantially transverse to the guideway centerline, wherein a first plane perpendicular to the axis of rotation of one of the wheels passes through the centroid of its respective contact zone, and a second plane perpendicular to the axis if rotation of the other wheel passes through the centroid of its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to the guideway centerline at or near the intersection line

are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

17. A vehicle as claimed in Claim 16, wherein the intersection line passes through the center of gravity of vehicle.

18. A vehicle as claimed in Claim 14, wherein the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset.

19. A vehicle as claimed in Claim 15, wherein the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset.

20. A vehicle as claimed in Claim 16, wherein the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset.

21. A vehicle as claimed in Claim 14, wherein the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

22. A vehicle as claimed in Claim 15, wherein the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

23. A vehicle as claimed in Claim 16, wherein the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

24. A vehicle as claimed in Claim 14, wherein the longitudinally disposed reference path is substantially contiguous with the guideway centerline.

25. A vehicle as claimed in Claim 15, wherein the longitudinally disposed reference path is substantially contiguous with the guideway centerline.

26. A vehicle as claimed in Claim 16, wherein the longitudinally disposed reference path is substantially contiguous with the guideway centerline.

27. A vehicle as claimed in Claim 14, wherein the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centerline.

28. A vehicle as claimed in Claim 15, wherein the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centerline.

29. A vehicle as claimed in Claim 16, wherein the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centerline.

30. A vehicle as claimed in Claim 14, wherein a secondary running face lies immediately adjacent to, and substantially parallel to, at least one of the primary running faces.

31. A vehicle as claimed in Claim 15, wherein a secondary running face lies immediately adjacent to, and substantially parallel to, at least one of the primary running faces.

32. A vehicle as claimed in Claim 16, wherein a secondary running face lies immediately adjacent to, and substantially parallel to, at least one of the primary running faces.

33. A vehicle as claimed in Claim 30, wherein the longitudinally disposed reference path is contiguous with the second running face.

34. A vehicle as claimed in Claim 31, wherein the longitudinally disposed reference path is contiguous with the second running face.

35. A vehicle as claimed in Claim 32, wherein the longitudinally disposed reference path is contiguous with the second running face.

36. A vehicle as claimed in Claim 14, wherein a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centerline between the respective two secondary running faces.

37. A vehicle as claimed in Claim 15, wherein a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centerline between the respective two secondary running faces.

38. A vehicle as claimed in Claim 16, wherein a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centerline between the respective two secondary running faces.

39. A vehicle as claimed in Claim 30, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

40. A vehicle as claimed in Claim 31, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

41. A vehicle as claimed in Claim 32, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

42. A vehicle as claimed in Claim 33, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

43. A vehicle as claimed in Claim 34, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

44. A vehicle as claimed in Claim 35, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

45. A vehicle as claimed in Claim 36, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

46. A vehicle as claimed in Claim 37, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

47. A vehicle as claimed in Claim 38, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

48. A vehicle as claimed in Claim 14, wherein the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centerline.

A VEHICLE WITH A STEERABLE WHEELSET

TECHNICAL FIELD

This invention relates to a vehicle with a steerable wheelset. Whilst the invention is primarily described with an embodiment particularly suited for use with Automated Guideway Transit (AGT) systems of the type which use small, individual vehicles, capable of operating at high speeds, the present invention is also suitable for use with a variety of other rail or guideway systems.

BACKGROUND

There are a number of known vehicles adapted to travel on rail or guideway systems which have steerable wheelsets.

One such system is disclosed in US Patent 4,982,671 (Chollet et al), and relates to a track guided vehicle. Such a vehicle is supported on bogies, where each bogie contains two wheelsets. Magnetic (or other) sensors are used to detect the lateral position of the bogie with respect to the track on which it is running. At least one sensor detects the angle between the two wheelsets. The two wheelsets are connected via linkages and actuators, such that the angle between the wheelsets can be altered to steer the bogie. A servo-control circuit receives signals from the sensors and controls the actuators to steer the wheelsets in response to the detected lateral position of the bogie.

Another known system is disclosed in European Patent 374,290 (Girod et al), and relates to a track guided vehicle. Such a vehicle comprises four wheels that can be independently steered. Laser sensors, located at the front and rear of the vehicle, are used to detect the difference between the track centreline and the vehicle longitudinal axis. A servo-control mechanism controls the steering actuators in order to steer the wheels in response to the sensed signals.

A disadvantage of both of these arrangements is that the lateral forces at the wheel-rail contact zone must serve a dual function, namely to steer the bogie and to oppose any lateral force, such as the centrifugal force experienced by a vehicle while cornering. Consequently the force available for steering the bogie is limited to the difference between the total available force and that already being used to oppose any external lateral forces. In a rail application where a steel wheel rolls on a steel rail, the total available force may be very low. This available force may be substantially required to react centrifugal force, with very little remaining force available to steer the wheelset leading to frequent contact between the wheel flanges and the rails.

A further known system is disclosed in US Patent 5,730,064 (Bishop), and relates to a self-steering bogie for track guided vehicle. The wheelsets are arranged such that a curvature in the rail generates a twist angle between the two wheelsets in the bogie when viewed in end elevation. The mechanism connecting the two wheelsets is arranged so as to steer the wheelsets, in response to rail curvature. A disadvantage of this arrangement when applied to small vehicle guideway systems, which typically use much sharper curves than normal rail systems, is the steer error resulting from twist angle supplied by rapidly changing superelevation. This may add to or subtract from the ideal steering angle required, causing the wheelset to deviate from its idealised path.

Preferably the present invention overcomes the above mentioned disadvantages by providing a vehicle with a steerable wheelset in which the effect of lateral or disturbing forces on the vehicle is minimised.

SUMMARY OF INVENTION

In one aspect the present invention is a vehicle with at least one steerable wheelset adapted to run on a guideway having two primary running faces laterally offset about

a guideway centreline, the wheelset comprising a pair of wheels, each wheel located on opposite sides of the wheelset adapted to

engage with a respective one of the two primary running faces, the vehicle further comprising sensing means for sensing lateral displacement of the wheelset with respect to a longitudinally disposed reference path, the sensing means producing a signal for a control system operably connected to an actuating means to steer the wheels in response to the sensed lateral displacement, **characterised in that** the axes of rotation of the wheels and the primary running faces are inclined downwardly towards the guideway centreline.

In a first embodiment each wheel exerts an engagement force with its respective primary running face, the engagement force on each wheel comprising a perpendicular component to its respective primary running face and a parallel component to its respective primary running face substantially transverse to the guideway centreline, wherein horizontal forces acting on the wheelset substantially perpendicular to the guideway centreline are substantially resisted by the sum of of the horizontal vectors of the perpendicular components.

In a second embodiment embodiment each wheel exerts an engagement force with its respective primary running face at a contact zone, the engagement force on each wheel comprising a first component perpendicular to its respective primary running face and a second component parallel to its respective primary running face substantially transverse to the guideway centreline, wherein a first plane perpendicular to the axis of rotation of one of the wheels passes through its respective contact zone, and a second plane perpendicular to the axis of rotation of the other wheel passes through its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to

the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

Preferably the intersection line passes through the centre of gravity of vehicle.

It is preferred that the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset. Alternatively the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

It is preferred that the longitudinally disposed reference path is substantially contiguous with the guideway centreline.

Alternatively, it is preferred that the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

It is preferred that a secondary running face lies immediately adjacent to, and substantially parallel to, at least one primary running face.

It is preferred that the longitudinally disposed reference path is contiguous with the second running face.

Alternatively, it is preferred that a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

It is preferred that at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

It is preferred that the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an example of a vehicle according to the prior art, with two steerable wheelsets and incorporating steering sensors, actuators and a controller;

Figure 2 is a wheelset as found in the vehicle in Figure 1, showing the forces acting at the wheel-to-guideway running faces;

Figure 3 is a graph representing a typical relationship between side-force and slip angle for a wheel of the wheelset in Figure 2, and showing the force available for steering the wheels;

Figure 4 shows a schematic representation of a vehicle in accordance with a first embodiment of the present invention;

Figure 5 shows a schematic representation of a vehicle as shown in figure 4 when the vehicle is in a turn;

Figure 6 is a wheelset of the vehicle as shown in Figures 4-5, showing the forces acting at the wheel-to-guideway running faces;

Figure 7 is a graph similar to Figure 3, showing the force substantially available to steer the wheels in accordance with the first embodiment of the present invention;

Figure 8 is an illustration of the forces which act on the wheelset of the vehicle shown in Figure 6.

Figure 9 is a wheelset and rails as described in a second embodiment of the present invention;

Figure 10 shows a wheelset which is following a longitudinally disposed reference path other than the guideway centreline or secondary running face, according to a third embodiment of the present invention.

MODE OF CARRYING OUT THE INVENTION

Figures 1 and 2 show a vehicle running on a guideway (or track) of the type described in prior art. Such a vehicle incorporates two steerable wheelsets 1, attached to a vehicle body 2, and each wheelset 1 comprising axle 10 and two wheels 12. Steering actuators 3, are used to control the angle of the wheels with respect to the body. Sensors 4, detect the path error between the vehicle and guideway 5. A controller 6, processes the signals from the sensors and provides a control output to steering actuators 3. Upon detecting a path error, wheelsets 1 are steered in order to minimise the error.

In such a vehicle, axles 10 are substantially horizontal, as shown in Figure 2. When a lateral force F is applied to the vehicle body 2, it is reacted by the wheel-to-guideway engagement forces. These reaction forces can be resolved into perpendicular components, A_N and B_N, and parallel components, A_T, B_T. When a wheel is steered at an angle to its heading, generating a slip angle, small levels of slip at its contact zone generate a lateral force (A_T, B_T). This lateral force is related

to this slip angle, with a typical relationship of the form shown in the graph of Figure 3. Such a relationship depends on both the wheel and guideway materials, along with their surface texture and lubrication. The available side force reaches a maximum at a slip angle δ_1, beyond which no additional side force is available. In the example shown in Figure 2, wheelset 1 is steered so that lateral force F is reacted by a combination of A_T and B_T where A_T is equal to C_1 as shown graphically in Figure 3. To generate a force C_1 wheelset 1 must be steered so that wheel 12 generates a slip angle δ_0 to its heading. Only the remaining force C_2 is available to steer wheelset 1. If the required side force exceeds C_2, steering control is lost, the wheel slides in the direction of force F and is unable to follow a desired path. In such an event, the wheelset must rely on other means, such as wheel flanges, to ensure it remains safely on the guideway.

Figures 4 to 6 show a first embodiment of a vehicle according to the present invention comprising steerable wheelsets 21, each comprising axle 26 and two wheels 15 running on primary running faces 54 of guideway 19, attached to vehicle body 16. Steering actuators 17, are used to control the angle of wheelsets 21 with respect to vehicle body 16. Sensors 18, detect the lateral displacement between the vehicle and guideway 19. Controller 20 processes the signals from sensors 18, and provides an output to the steering actuators as a function of the lateral displacement of wheelset 21 with respect to guideway centreline 39. Upon detecting a lateral displacement error, wheelsets 21 are steered in order to minimise the error.

As shown in Figure 6, axes of rotation 28 of wheels 15 (mounted to stub axles 25) are inclined downwardly towards guideway centreline 39, as are primary running faces 54 at the wheel-to-guideway rolling interface. When a lateral force F is similarly applied to vehicle body 16, it is reacted by the wheel-to-guideway engagement forces. These can be resolved into first perpendicular components, P_N and Q_N and second parallel components, P_T and Q_T. Each of these has a

component parallel to the applied lateral force F, and in combination react against this force.

On entering a turn, sensors 18 detect the deviation of the vehicle from guideway centreline 39, and controller 20 responds by steering wheelset 21 in the direction to reduce the deviation to zero. The resulting slip angle δ produces lateral forces at the wheel-to-guideway interface, causing the vehicle to accelerate toward the instantaneous centre of curvature. The centrifugal force F, acting on the centre of gravity 50 of the vehicle, is substantially reacted by an increase in the normal force, P_N, on the outer wheel, rather than an increase of the tangential forces, P_T and Q_T. If P_T and Q_T are small, then the wheels do not need to be operating at a very large slip angle δ_o as shown in Figure 7. As a result, most of the maximum available tangential force, C_2, can be used to steer wheelset 21 and maintain its alignment with guideway centreline 39.

It is preferred that vehicle centre of gravity 50 and wheels 15 are arranged such that centre of gravity 50 is near the intersection line 52 of wheel planes 51. In this configuration, the centrifugal forces or external disturbance forces acting on centre of gravity 50, are substantially resisted by an increase in the normal force, P_N, on the outer wheel, and corresponding decrease in the normal force Q_N on the inner wheel. As shown in Fig 8., the difference between the horizontal component P_H of P_N and the horizontal component Q_H of Q_N, substantially resists the sum of the centrifugal or external disturbance force F.

Figure 9 depicts a second embodiment of the present invention, where the vehicle has a wheelset 21 comprising wheels 15 adapted to run on a guideway in the form of rails 19. Sensors 18 detect the proximity d_1, d_2 of the respective wheel 15 to the respective secondary running face 38 on rail 19. Sensed proximities d_1, d_2 are

averaged to generate the lateral position of the centreline 49 of the wheelset 21, with respect to the guideway centreline 39. In this embodiment each of the wheels 15 have a respective flange 37. Flange 37 engages with respective secondary running face 38 on rail 19 in the event of a steering failure, or excessive side load imparted on the vehicle via lateral acceleration or side wind loads. In other not shown embodiments, sensors 18 may detect the proximity of the wheels to some other feature on rail 19.

In a third embodiment of the invention as shown in Figure 10, sensors 18 may sense a different path to that of guideway running faces 40. In this embodiment a longitudinally disposed reference path 41, corresponding to the guideway centreline 39, is used. However, it should be understood that such a path may physically lie between guideway running faces 40, as depicted by phantom lines as reference path 41a and sensor 18a, or outside guideway running faces 40, as depicted by phantom lines as reference path 41b and sensor 18b. Alternatively the reference path may be a virtual path, bearing some predetermined varying relationship to the guideway running faces 40.

In other not shown embodiments other means of supporting and steering the wheels may be used. These include steering of individual wheels about individual steering axes, rather than steering complete wheelset 21. Sensors 18, are attached to wheelset 21, and sense its lateral displacement with respect to each primary running face 54 of guideway 19 and hence with respect to guideway centreline 39. Sensors 18 are preferably located ahead of wheelset 21 and are connected to controller 20. In other not shown embodiments, sensors 18 may be located ahead, beside, and/or even behind the wheels.

Sensors 18, controller 20 and actuators 17 may include hydraulic or electrical devices and combinations thereof.

It will be recognised by persons skilled in the art that numerous variations and modifications may be made to the invention without departing from the spirit and scope of the invention.

CLAIMS:

1. A vehicle with at least one steerable wheelset adapted to run on a guideway having two primary running faces laterally offset about a guideway centreline, the wheelset comprising a pair of wheels, each wheel located on opposite sides of the wheelset adapted to engage with a respective one of the two primary running faces, the vehicle further comprising sensing means for sensing lateral displacement of the wheelset with respect to a longitudinally disposed reference path, the sensing means producing a signal for a control system operably connected to an actuating means to steer the wheels in response to the sensed lateral displacement, **characterised in that** the axes of rotation of the wheels and the primary running faces are inclined downwardly towards the guideway centreline.

2. A vehicle as claimed in claim 1, wherein each wheel exerts an engagement force with its respective primary running face, the engagement force on each wheel comprising a perpendicular component to its respective primary running face and a parallel component to its respective primary running face substantially perpendicular to the guideway centreline, wherein horizontal forces acting on the wheelset substantially transverse to the guideway centreline are substantially resisted by the sum of the horizontal vectors of the perpendicular components.

3. A vehicle as claimed in claim 1, wherein each wheel exerts an engagement force with its respective primary running face at a contact zone, the engagement force on each wheel comprising a first component perpendicular to its respective primary running face and a second component parallel to its respective primary running face substantially transverse to the guideway centreline, wherein a first plane perpendicular to the axis of rotation of one of the wheels passes through the centroid of its respective contact zone, and a

second plane perpendicular to the axis of rotation of the other wheel passes through the centroid of its respective contact zone, the first and second planes intersecting along an intersection line disposed above and between the wheels, wherein horizontal forces acting on the wheelset substantially transverse to the guideway centreline at or near the intersection line are substantially resisted by perpendicular components of the engagement forces acting at the primary running faces, such that substantially all of the parallel components of the engagement forces acting at the primary running faces are available to steer the wheelset.

4. A vehicle as claimed in claim 3, wherein the intersection line passes through the centre of gravity of vehicle.

5. A vehicle as claimed in claims 1 to 3, wherein the sensing means comprises at least one sensor located either ahead or behind the wheelset, or laterally offset with the wheelset.

6. A vehicle as claimed in claims 1 to 3, wherein the sensing means comprises at least two sensors, one of which is located ahead of the wheelset and the other is located behind the wheelset.

7. A vehicle as claimed in claims 1 to 3, wherein the longitudinally disposed reference path is substantially contiguous with the guideway centreline.

8. A vehicle as claimed in claims 1 to 3, wherein the longitudinally disposed reference path is substantially parallel to, but laterally offset from the guideway centreline.

9. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to, and substantially parallel to, at least one of the primary running faces.

10. A vehicle as claimed in claim 9, wherein the longitudinally disposed reference path is contiguous with the second running face.

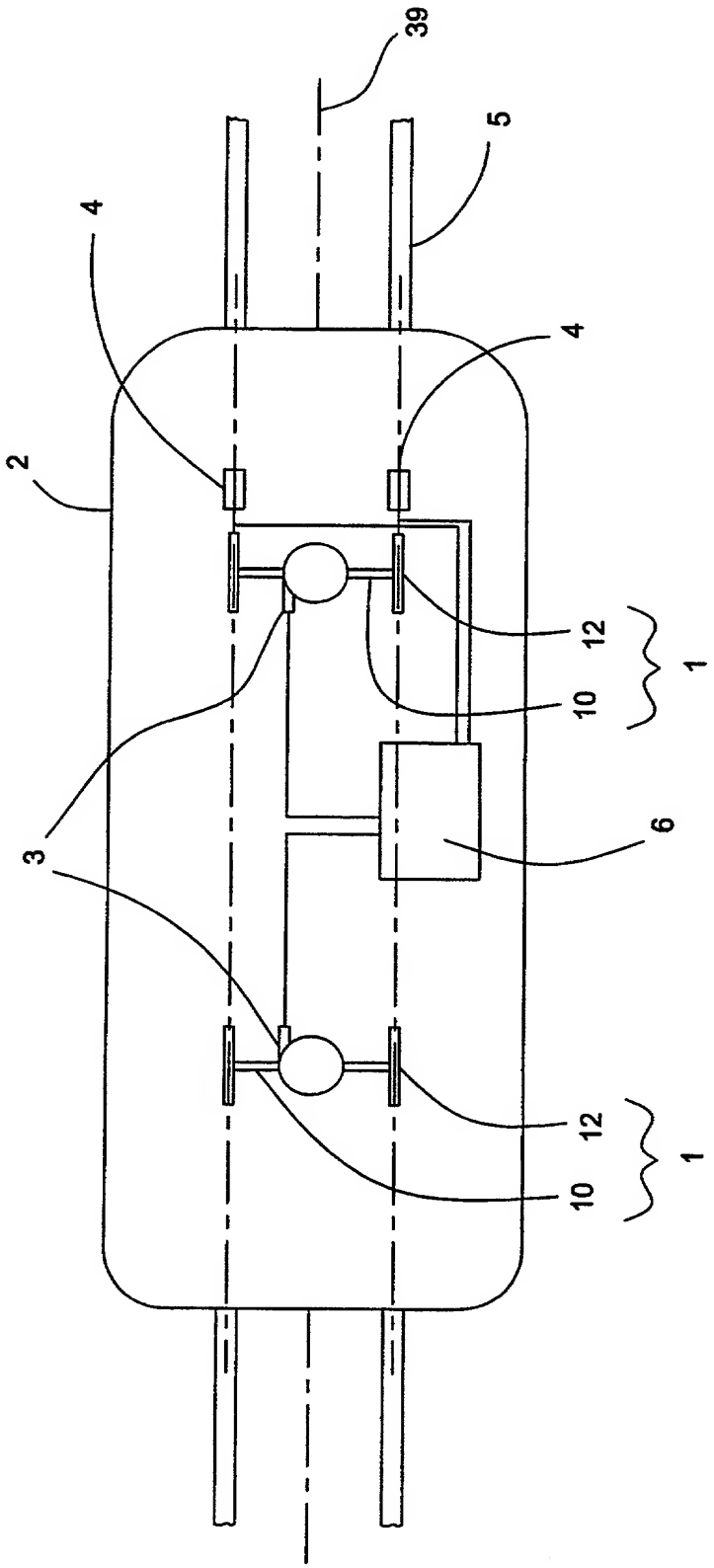
11. A vehicle as claimed in claims 1 to 3, wherein a secondary running face lies immediately adjacent to and substantially parallel to each primary running face and the longitudinally disposed reference path is contiguous with the lateral centreline between the respective two secondary running faces.

12. A vehicle as claimed in claims 9 to 11, wherein at least one of the wheels also incorporates a flange, adapted to engage with the secondary running face.

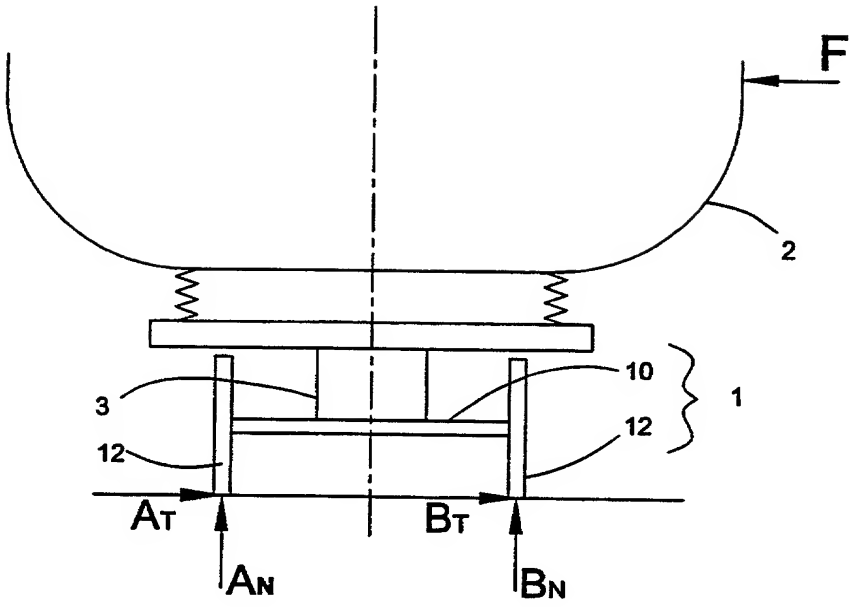
13. A vehicle as claimed in claim 1, wherein the control system calculates a virtual longitudinally disposed reference path which is not necessarily parallel or contiguous with the guideway centreline.

ABSTRACT

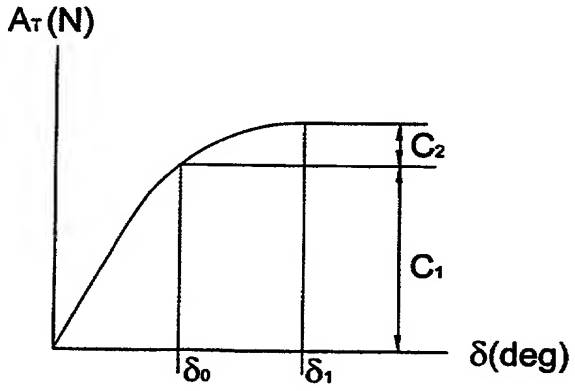
A vehicle where respective inwardly inclined wheels (15) of a steerable wheelset run on respective inwardly sloping faces (54) of a guideway having centreline (39). The vehicle having sensing means for sensing lateral displacement of the wheelset relative to a longitudinal reference path. The sensing means signalling a control system including actuating means to steer the wheelset in response to sensed lateral displacement thereof.



PRIOR ART
Figure 1



PRIOR ART
Figure 2



PRIOR ART
Figure 3

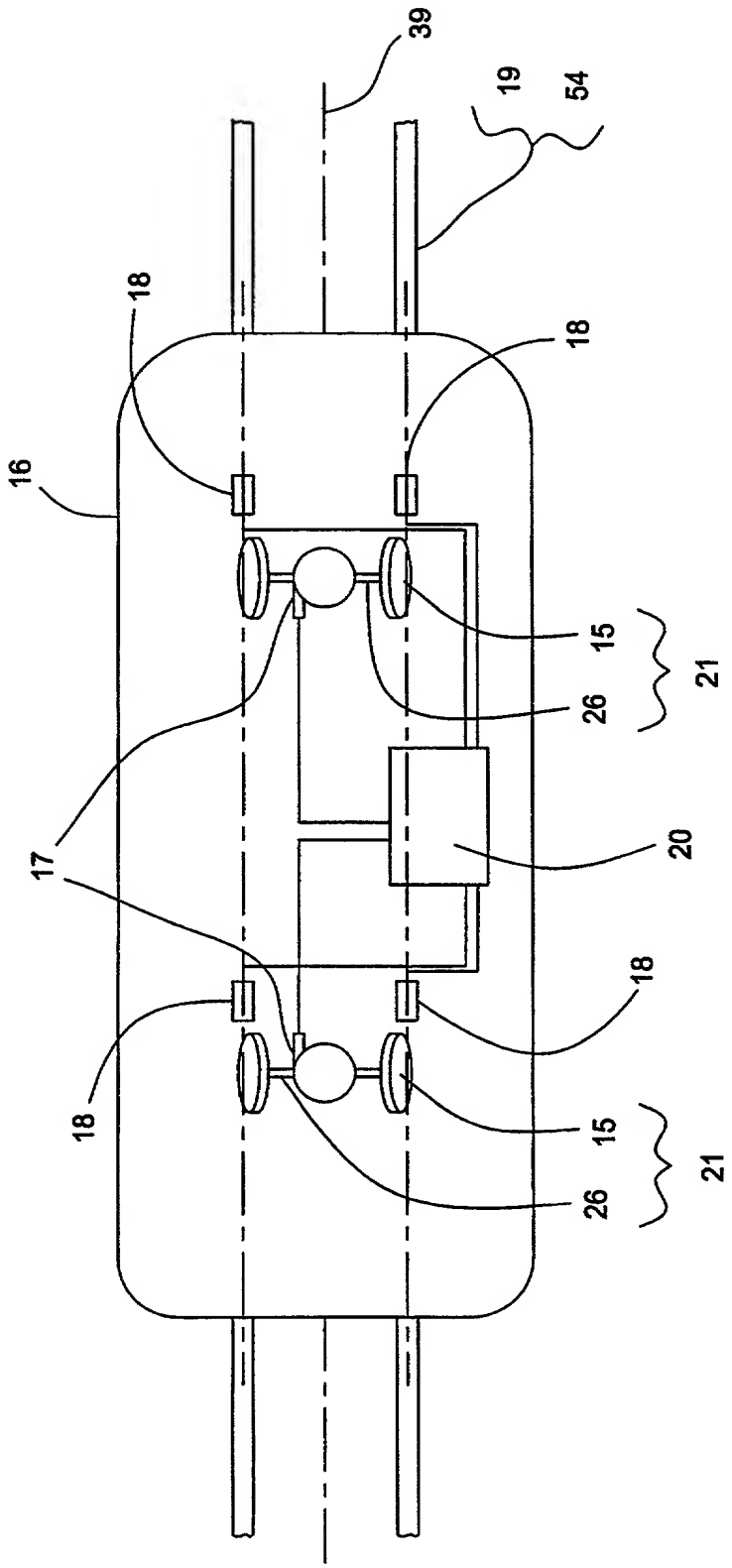


Figure 4

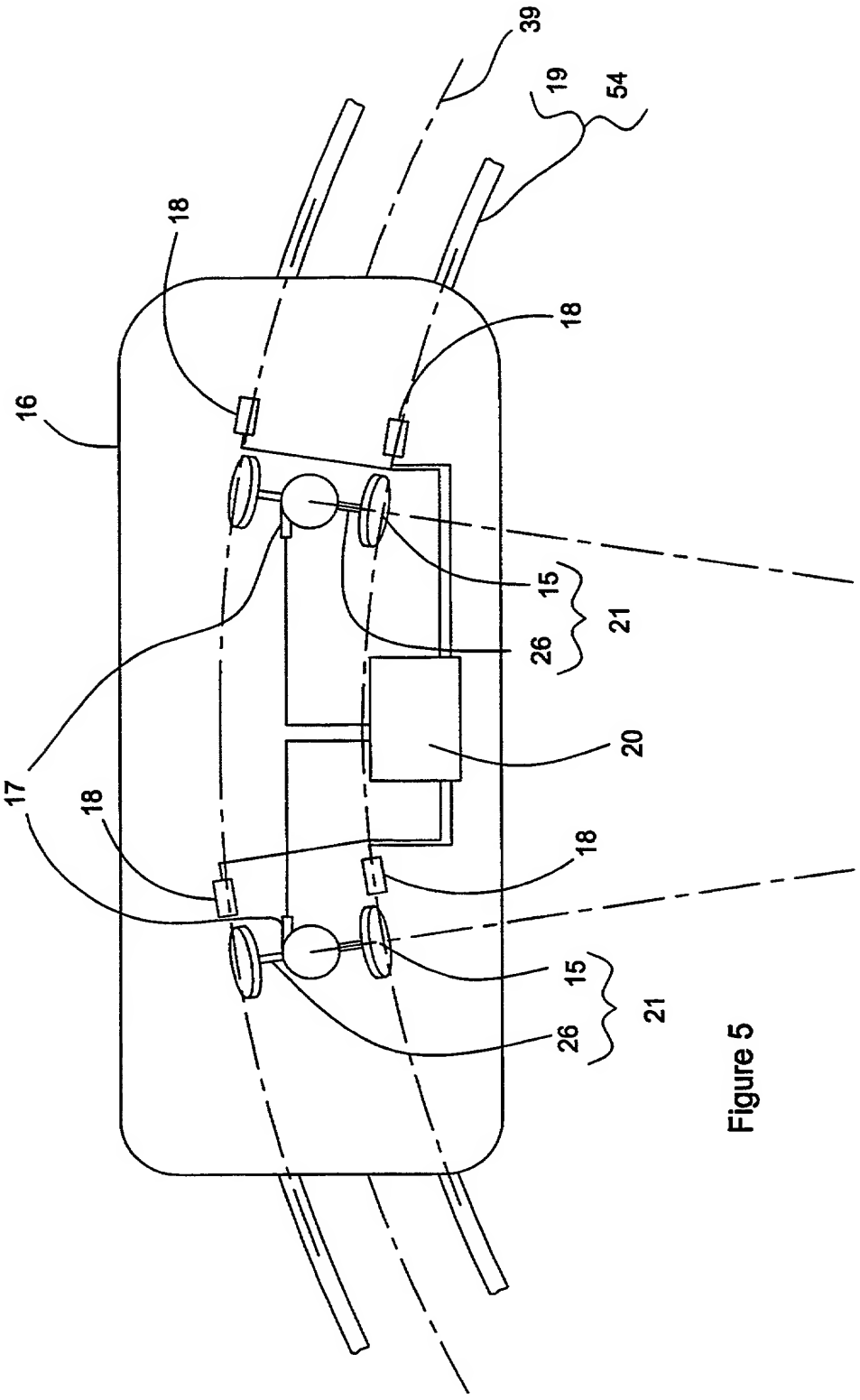


Figure 5

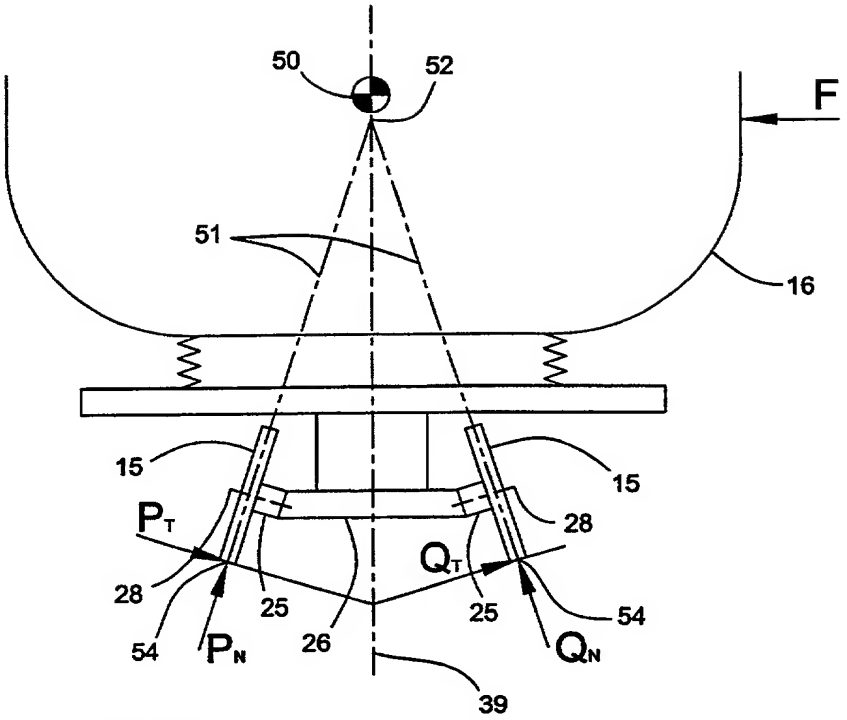


Figure 6

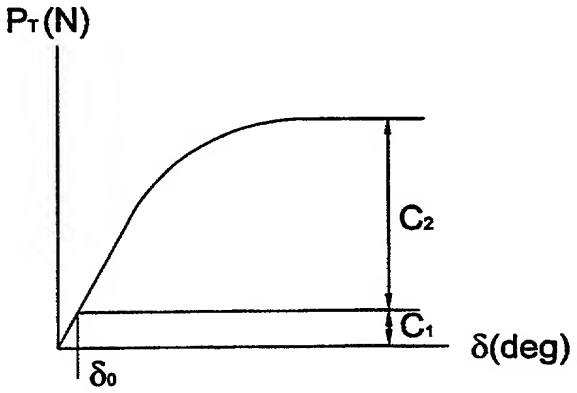


Figure 7

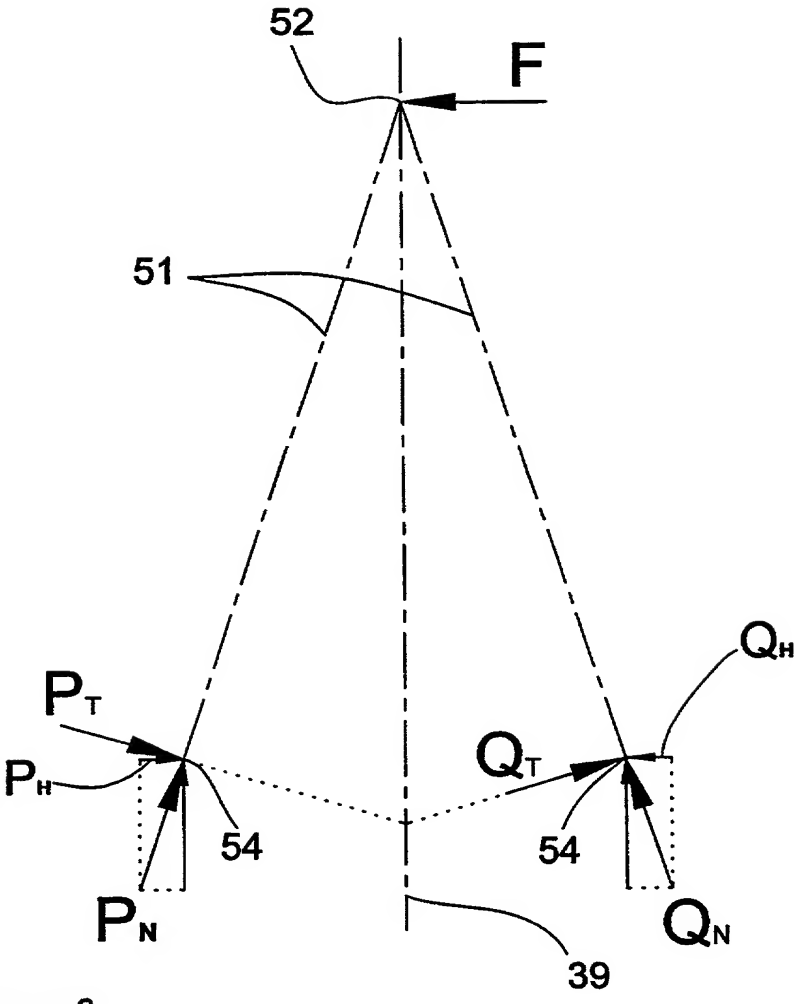


Figure 8

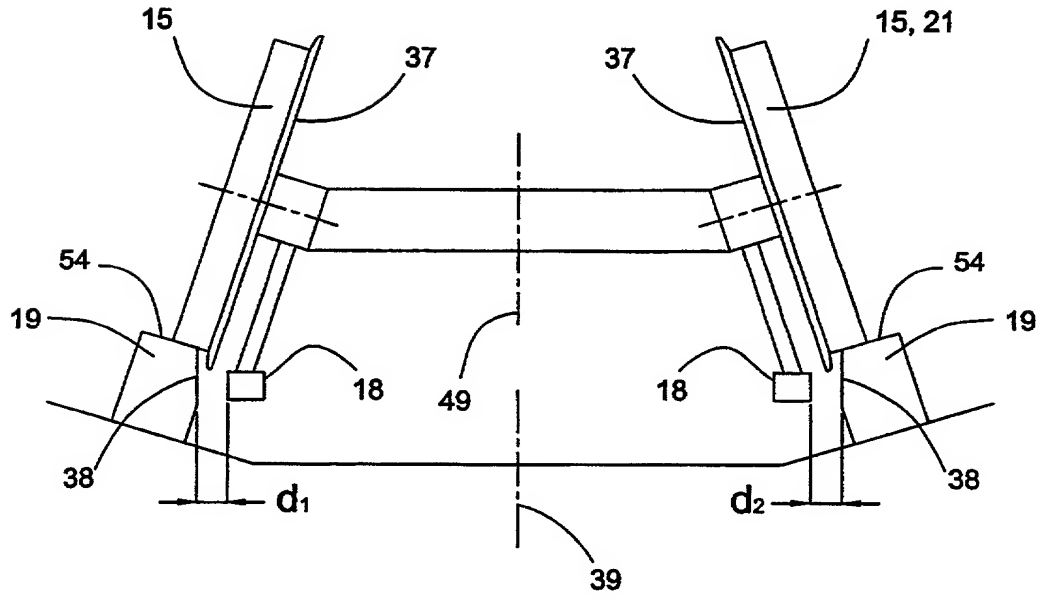


Figure 9

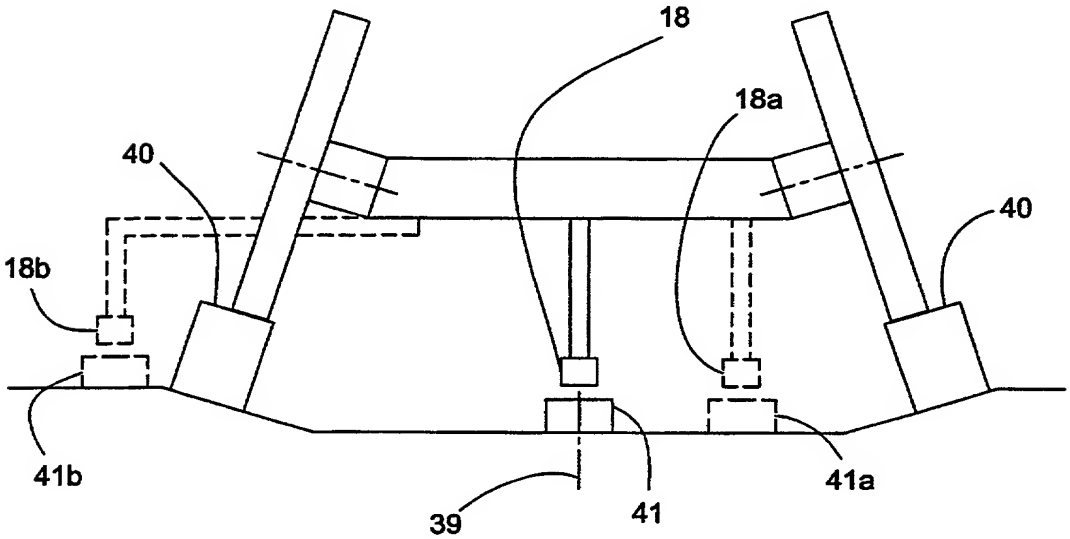


Figure 10

L 698 184 700
PATENT

Docket: CU-2825

COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION OR CIP)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type: *(check one applicable item below)*

- ☐ original
- ☐ design
- ☐ supplemental

Note: If the Declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.

- ☒ national stage of PCT

Note: If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR CIP.

- ☐ divisional
- ☐ continuation
- ☐ continuation-in-part (CIP)

INVENTORSHIP IDENTIFICATION

WARNING: If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

A VEHICLE WITH A STEERABLE WHEELSET

SPECIFICATION IDENTIFICATION

the specification of which: *(complete (a), (b) or (c))*

☐ (a) is attached hereto.

☐ (b) was filed on _____ as ☐ Serial No. _____ or
☐ Express Mail No. *(as Serial No. not yet known)* _____
and was amended on _____ *(if applicable).*

Note: Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the Declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental Declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 CFR 1.67.

☒ (c) was described and claimed in PCT International Application No. PCT/AU00/00898 filed on 28 July 2000.

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56,

(also check the following items, if desired)

☐ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

☐ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 CFR 1.98.

PRIORITY CLAIM (35 U.S.C. § 119(a)-(d))

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

☐ (d) no such applications have been filed.

☒ (e) such applications have been filed as follows.

Note: Where item (c) is entered above and the international application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119(a)-(d)

COUNTRY (OR INDICATE IF PCT	APPLICATION NUMBER	DATE OF FILING (day/month/year)	PRIORITY CLAIMED UNDER 35 USC 119
Australia	PQ 2103	10 August 1999	☒ YES NO ☐
Australia	PQ 4352	01 December 1999	☒ YES NO ☐

CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S) (35 U.S.C. § 119(e))

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

PROVISIONAL APPLICATION NUMBER	FILING DATE

ALL FOREIGN APPLICATION(S), IF ANY, FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

_____

_____

Note: If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR CIP APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. § 120.

POWER OF ATTORNEY

I hereby appoint the following practitioner(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*.

Thomas F. Peterson, 24790; Richard J. Streit, 25765; Donald P. Reynolds, 26220; W. Dennis Drehkoff, 27193; Vangelis Economou, 32341; Brian W. Hameder, 45613; Valerie Neymeyer-Tynkov, 46956; Paul B. West, 18947; Joseph H. Handelman, 26179; Peter D. Galloway 27885; John Richards, 31503; Iain C. Baillie, 24090; Richard P. Berg, 28145 (13)

☐ Attached, as part of this declaration and power of attorney, is the authorization of the above-named practitioner(s) to accept and follow instructions from my representative(s).

SEND CORRESPONDENCE TO:

Richard J. Streit
c/o Ladas & Parry
224 South Michigan Avenue
Suite 1200
Chicago, Illinois 60604

DIRECT TELEPHONE CALLS TO:
(Name and telephone number)

(312) 427-1300

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

Note: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other documents.

Full name of sole inventor

Scott	Phillip Neale	TAYLOR
(Given Name)	(Middle Initial or Name)	(Family (or Last) Name)

Inventor's signature S P Taylor

Date 14 FEBRUARY 2002 **Country of Citizenship** Australia

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